

**CLAIMS:**

1. A polymer article comprising a polymer matrix and inorganic ultrafine particulate material evenly distributed through the polymer matrix characterised in that the inorganic particulate material has a particle size up to  
5 10  $\mu\text{m}$  at a particle loading of 0.01 – 20 wt% based on the total weight of the polymer inorganic components.
2. The article of claim 1, wherein the particle size is in the range of 1 to 1000 nanometers.
3. The article according to claim 1, wherein the upper size limit of the particle  
10 is less than 800 nanometers.
4. The article according to claim 1, wherein the particulate material has a size range of between 100-800 nanometers.
5. The article according to any one of claims 1-4, wherein the upper particle loading limit is 10 wt% based on the total weight of polymeric and inorganic  
15 material.
6. The article of claim 1, wherein the interparticle distance between the particles is less than 20 $\mu\text{m}$  and the average interparticle distance is in the range of 2  $\mu\text{m}$  to 10  $\mu\text{m}$ .
7. The article according to claim 1, wherein the inorganic particulate material  
20 is an inorganic material available in submicron powder form, or a precursor to said inorganic particulate material, selected from the group including metal oxides, metal silicates and metal alkoxides.
8. The article according to claim 7, wherein the particulate material is an oxide, silicate and alkoxide of aluminium, titanium and silicon.
- 25 9. The article according to claim 7, wherein the particulate material is selected from the group consisting of alumina, ( $\text{Al}_2\text{O}_3$ ), titania ( $\text{TiO}_2$ ), zirconia ( $\text{ZrO}_2$ ), silica ( $\text{SiO}_2$ ), silicon carbide, hydroxides of alumina and alumino- silicates.
10. The article according to claim 1, wherein the polymeric material is a thermosetting polymer.
- 30 11. The article according to claim 10, wherein the polymeric material is a

polyurethane, polyester, hybrid or copolymer thereof.

12. A method of forming a polymer-inorganic composite article comprising the steps of:

5 dispersing an inorganic submicron particulate material having a particle size up to 10  $\mu\text{m}$  in a polymer at a loading rate of 0.01 to 20 wt% of the total weight of polymer and inorganic material, the dispersion step preventing the formation of gas bubbles in the mixture to provide a dispersion having a substantially even distribution of particulate material in the polymer; and

casting the dispersion in a mould to cure the mixture.

10 13. The method of claim 12, wherein the particle size is in the range of 1 to 1000 nanometers.

14. The method according to claim 13, wherein the mixing is carried out to minimise the amount of agglomeration of dispersed particles and provide a substantially even distribution of particles in the polymer.

15 15. The method according to claim 14, wherein the mixing step includes milling the particulate material with the polymer under sub-atmospheric conditions.

16. The method of claim 15, wherein the mixing is carried out in a low shear regime having a Reynolds number less than or equal to 1000.

17. The method of claim 15, wherein the mixing is carried out in a high shear  
20 regime having a Reynolds number much greater than 1000.

18. The method of claim 16, wherein the particulate material is coated or treated with a dispersing agent to match the hydrophobicity of the particles with the polymer.

19. The method of claim 18, wherein the dispersing or compatibilizing agent is  
25 selected from the group consisting of non-alcohol or non amine aromatic solvent.

20. The method of any one of claims 12 to 19, wherein the mixing occurs at under vacuum conditions to ensure no bubbles are formed in the dispersion.

21. The method of any one of claims 12 to 19, wherein the mixing occurs under a pressure of less than one atmosphere to ensure no bubbles are formed in the  
30 dispersion

22. The method of claim 20 or 21, wherein the mixing is conducted in a vacuum oven at a temperature above melting temperature and below the decomposition temperature of the polymer.
23. The method of any one of claims 12 to 22, wherein the mixing takes place  
5 in a vacuum up to 760 mm Hg with the level dependent on the viscosity of the dispersion.
24. The method of claim 16, wherein the particulate material is mixed with a solvent prior to mixing with the polymer material.
25. The method of claim 24, wherein the solvent is removed by evaporation  
10 from the dispersion and the dispersion is cured to form a composite substantially free of gas bubbles.
26. The method of claim 17, wherein the inorganic particulate material is dispersed in the polymer by milling the particulate material and polymer at a mill temperature, above the melting temperature resin but below the decomposition  
15 temperature of the polymer resin at a pressure below atmospheric pressure.
27. The method of any one of claims 12 to 26, wherein after the mixing step polymerisation of the polymer is initiated by the addition of an initiator and the dispersion cured.
28. The method of any one of claims 12 to 26, wherein at least one other  
20 additive selected from the group consisting of anti static agents, fillers, pigments, optical brighteners and UV brighteners are added to the dispersion.
29. A method of dispersing an inorganic particulate material substantially homogenously in a polymer, the particulate material consisting essentially of particles having a particle size up to 10  $\mu\text{m}$  at a loading rate in the range of 0.01  
25 to 20 wt% based on the total weight of the particulate and polymer material, the method comprising the steps of combining the particulate material and a powder of the polymer under sub atmospheric pressure conditions, the combination being milled at a temperature above the melting temperature but below the decomposition temperature of the polymer to form a dispersion, and curing the  
30 dispersion.
30. The method of claim 29, wherein the particle size is in the range of 1 to

1000 nanometers.

31. The method of claim 30, wherein the particulate material is added to a solvent carrier to form a slurry prior to addition to the polymer, the solvent carrier being evaporated from the dispersion.

5 32. The method of claim 30 or 31, wherein the milling is conducted at a pressure of typically less than 900 millibar (gauge).

33. A method of increasing the wear resistance of a polymer comprising the steps of

10 dispersing an inorganic submicron particulate material having a particle size up to 10  $\mu\text{m}$  in a polymer at a loading rate of 0.01 to 20 wt% of the total weight of polymer and inorganic material, the dispersion step preventing the formation of gas bubbles in the mixture to provide a dispersion having a substantially even distribution of particulate material in the polymer; and

casting the dispersion in a mould to cure the polymer

15 34. The method of claim 33, wherein the particle size is in the range of 1 to 1000 nanometers.

35. The method according to claim 34, wherein the dispersing step is carried out to minimise the amount of agglomeration of dispersed particles and provide a substantially even distribution of particles in the polymer.

20 36. The method according to claim 35, wherein the mixing step includes milling the particulate material with the polymer under vacuum conditions.

37. The method of claim 36, wherein the mixing is carried out in a low shear regime having a Reynolds number less than or equal to 1000.

25 38. The method of claim 36, wherein the mixing is carried out in a high shear regime having a Reynolds number much greater than 1000.

39. The method of claim 37, wherein the particulate material is coated or treated with a dispersing agent to match the hydrophobicity of the particles with the polymer.

40. The method of claim 39, wherein the dispersing agent is PGMA.

30 41. The method of any one of claims 33 to 40, wherein the mixing occurs at

under vacuum conditions to ensure no bubbles are formed in the dispersion.

42. The method of any one of claims 33 to 40, wherein the mixing occurs under a pressure of less than one atmosphere to ensure no bubbles are formed in the dispersion

5 43. The method of claim 41 or 42, wherein the mixing is conducted in a vacuum oven at a temperature above melting temperature and below the decomposition temperature of the polymer.

44. The method of any one of claims 33 to 43, wherein the mixing takes place in a vacuum up to 760 mm Hg with the level dependent on the viscosity of the  
10 dispersion.

45. The method of claim 37, wherein the particulate material is mixed with a solvent prior to mixing with the polymer material.

46. The method of claim 45 wherein the solvent is evaporated from the dispersion and the dispersion is cured to form a composite substantially free of  
15 gas bubbles.

47. The method of claim 38, wherein the inorganic particulate material is dispersed in the polymer by milling the particulate material and polymer at a mill temperature, above the melting temperature but below the decomposition temperature of the polymer resin at a pressure below atmospheric pressure.

20 48. The method of any one of claims 33 to 47, wherein after the mixing step polymerisation of the polymer is initiated by the addition of an initiator and the dispersion cured.

49. The method of any one of claims 33 to 47, wherein at least one other additive selected from the group comprising anti static agents, fillers, pigments,  
25 optical brighteners and UV brighteners are added to the dispersion.